MONITORING EFFECTIVENESS OF IN SITU TREATMENT WITH REACTIVE AMENDMENTS OF CONTAMINATED SEDIMENTS IN AN ACTIVE DOD HARBOR

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Problem

- Active, deep-water DoD harbor areas pose significant challenges for remediation of contaminated sediment
- Effectiveness of traditional methods limited by typical DoD harbor conditions
  - Ships, tugs, prop wash
  - Piers, bulkheads, quay walls
  - Navigation requirements
  - Dewatering and disposal
  - Uncontrolled sources

Project Overview and Approach

- Demonstrate and validate placement, stability and performance of reactive amendments for treatment of contaminated sediments in an active DoD harbor setting (PSNS)
  - Placement in deeper water areas, near piers and structures
  - Effectiveness in controlling contaminant bioavailability
  - Physical stability and longevity in the sediment
  - Response of the benthic community

Laboratory Treatability Study (2011)

Performance Baseline Monitoring (2012)

AquaGate + PAC Installation (2012)

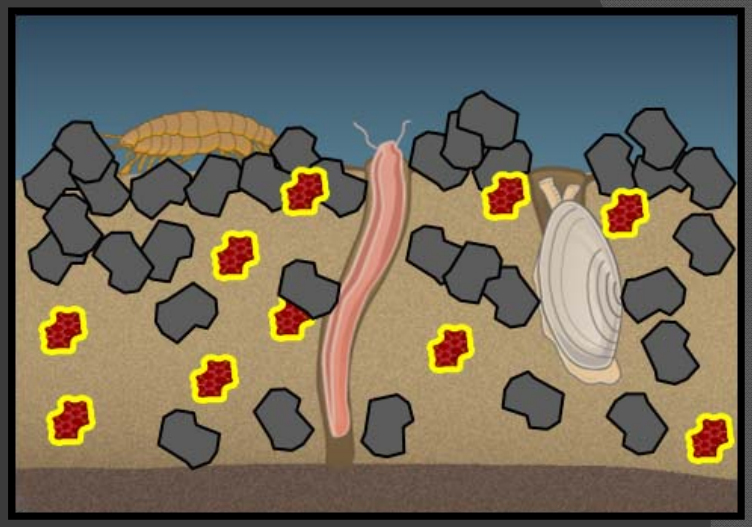
Construction and Performance Monitoring (2012-2013)

Persistence Monitoring (2014-2015)

Final Reports (2016)

Reactive Amendment Design

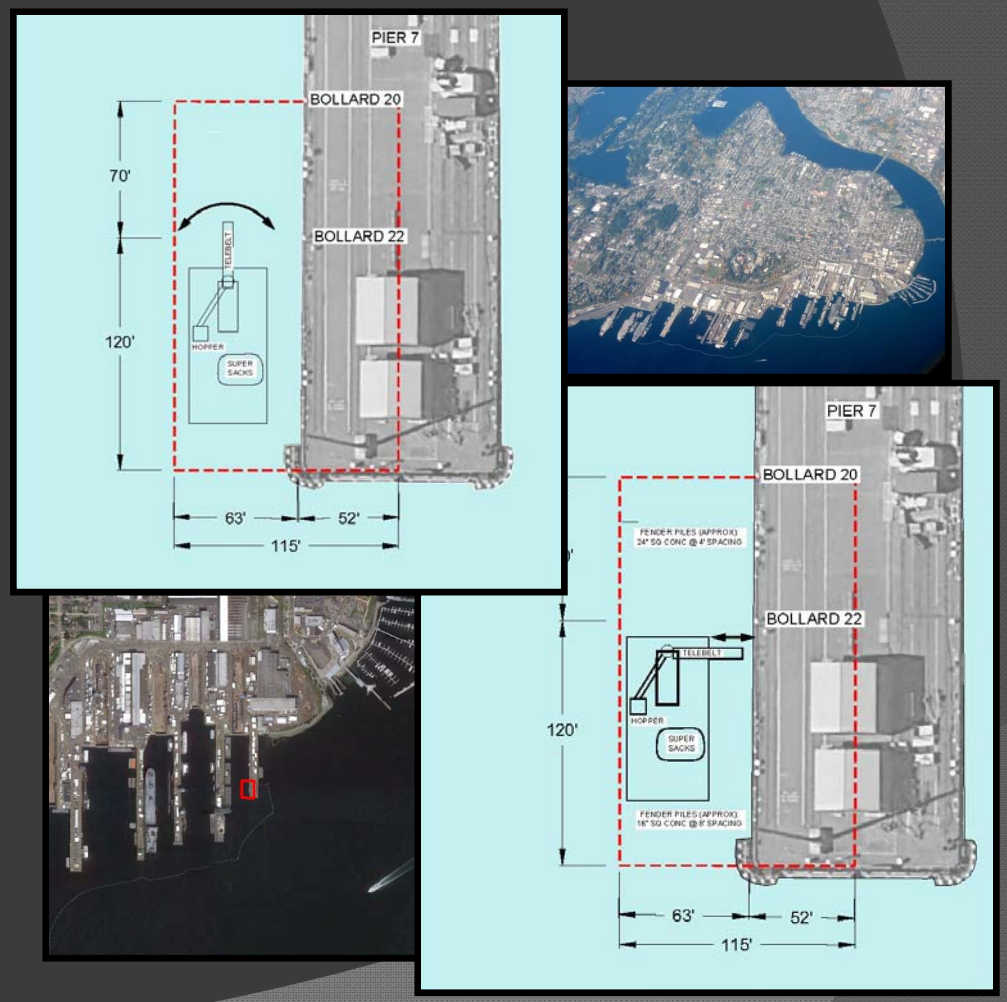
- Selected amendment is AquaGate+PAC™ (AquaBlok®, Toledo, Ohio)
- Utilizes coated aggregate/sand particles to achieve reliable placement
- Coating layer incorporates 5% Powder Activated Carbon (PAC) mixed with ~10% Bentonite binder to assure integrity during placement
- 141 tons = ~1.8” layer of amendment
  - Assuming 10 cm short-term mixing depth = 6% activated carbon
  - Assuming 20 cm long-term mixing depth = 3% activated carbon



Reactive amendment mixes into biologically active layers of sediment and sorbs freely-dissolved chemicals, reducing availability

Engineering Design for Amendment Placement

- Design placement area 115’ X 190’ (0.5 acres) at Puget Sound Naval Shipyard, Pier 7
- Include areas adjacent (190X65) to and underneath (190X50) the pier
- Include elevated areas identified by PCB screening (500 ppb - 6 ppm)
- Estimated 141 tons of amendment to achieve >3% carbon in top 10 cm

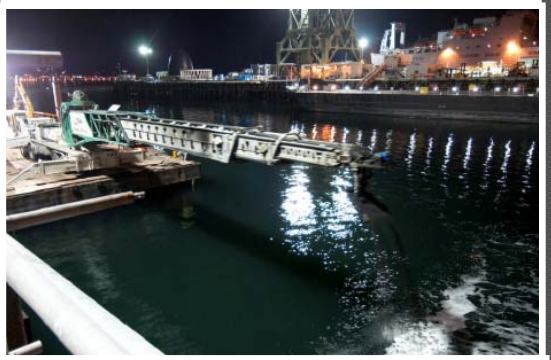


Amendment Shipment, Dry-Land Testing and Staging

"141 Super Sacks"
~2400 lbs/sack (~1 ton/sack)

Amendment Installation

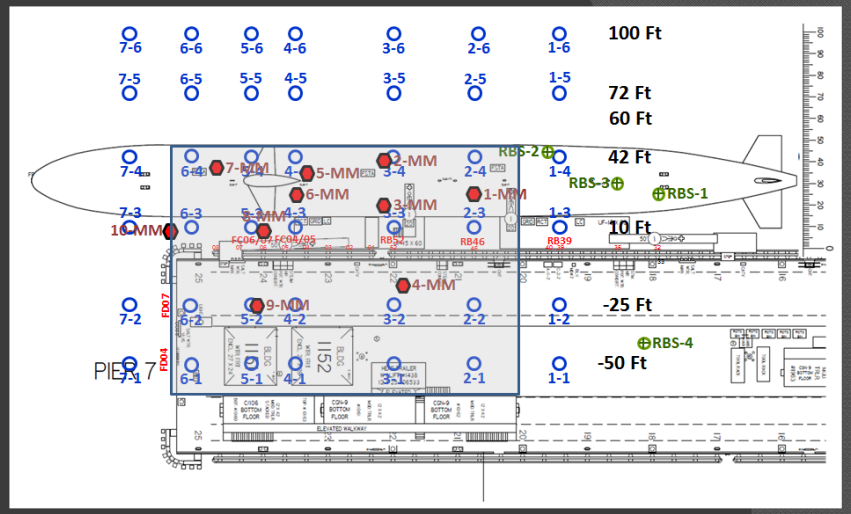
- Open Water
  - Articulated conveyor operating from a flat deck barge
  - 3 minute cycle time
  - Multiple passes to reduce windrows
- Under Pier
  - Conveyor extends under pier
  - Articulate between pilings
- Low-tide only for under dock (night ops)
- 141 tons (7 tons of carbon) of amendment successfully installed to target area



Pier 7 Amendment Installation
October 2012

Monitoring Methods

- Define the performance baseline for comparison of post-amendment monitoring events – physical, chemical and biological.

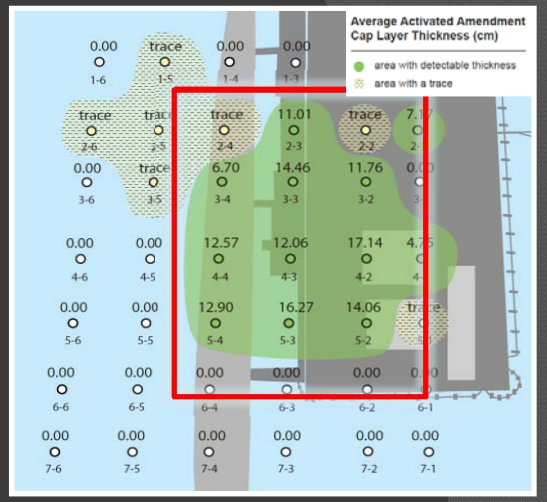


Line of Evidence	Time (months) (☑ Collected & analyzed; ● Collected; ○ Planned)						
	n	-2	0.5	3	10	21	34
Sediment TOC and Black Carbon Content; Grain Size	10	☑	☑	☑	☑	●	○
Sediment and freely-dissolved PCBs, Bioaccumulation and Benthic Census	10	☑			☑	●	○
Sediment Profile Imagery	42-50	☑	☑		☑	●	○
Reference Benthic Census Stations	4	☑			☑	☑	○
Sediment Hg and MeHg, Bioaccumulation (tracking)	10	☑			☑	●	○

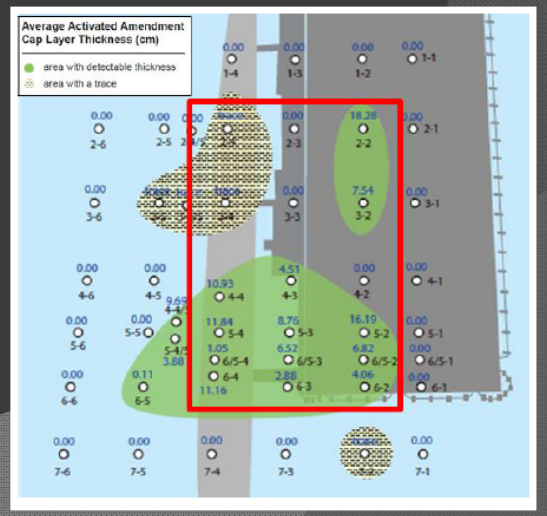
Evaluation of Amendment Application

Sediment Profile Imagery

- 0.5-month - ~70% of the target area received target thickness (5 cm)
- 10-month - ~70-75% of target area still covered
  - Amendment appears to have shifted south; detected at locations where it was not detected in previous survey



0.5 months

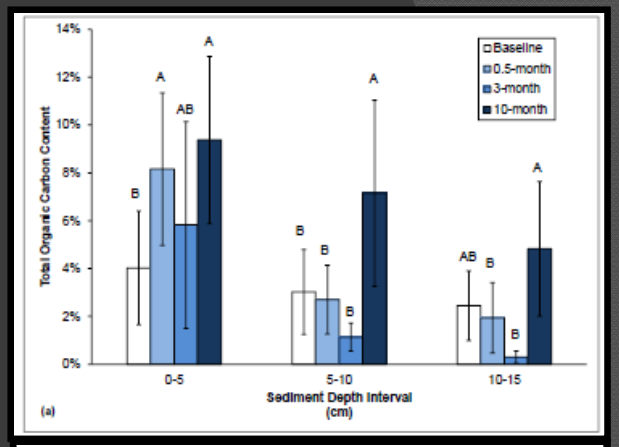


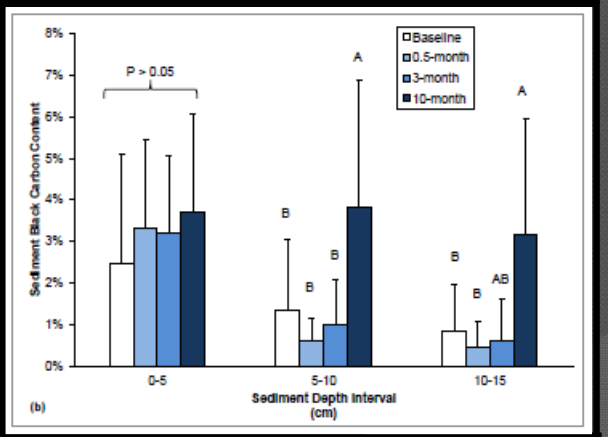
10 months

Evaluation of Amendment Application

Sediment Cores

- TOC and Black Carbon
  - Amendment rate: ~4% activated carbon by weight
  - Increase in Total Organic Carbon from ~4% to ~8% in top 10 to 15 cm (measured via analysis of core samples)
  - Increase in Black Carbon after 10 months in 5-10 cm and 10-15 cm
- Visual Analysis
  - Percentage of stations with aggregate, by depth
    - Top 5 cm: 90% of stations
    - 5-10 cm: 60% of stations
    - 10-15 cm: 40% of stations

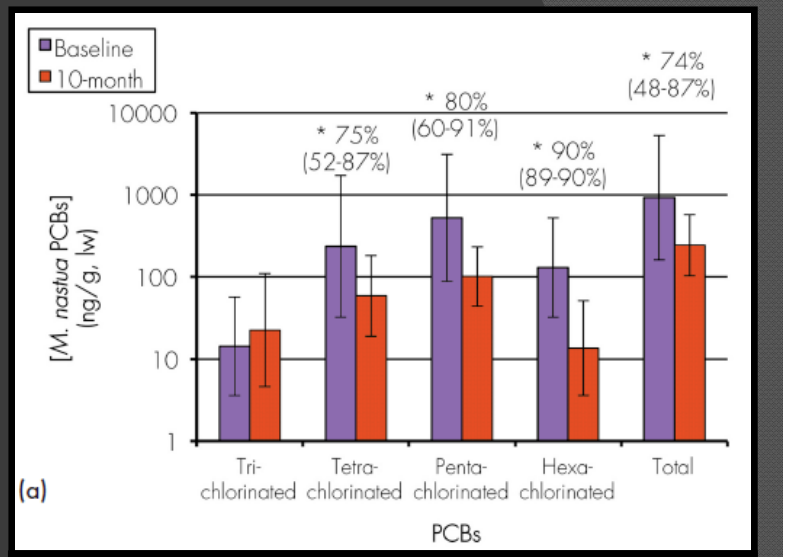


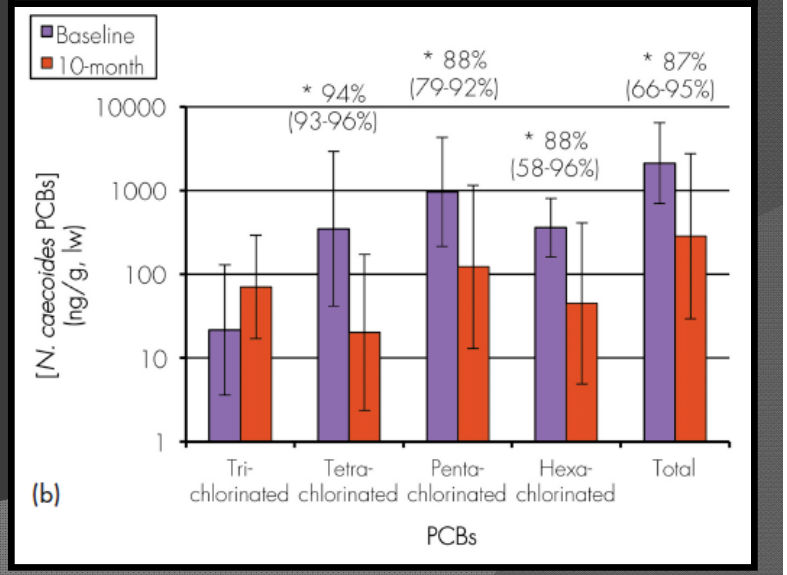


Evaluation of PCB Availability

Benthic Invertebrates

- Total PCB concentration in both clams and worms decreased ~ 80% following placement of amendment (10-mo)
  - *M. nasuta*: average of 74% (a)
  - *N. caecoides:* average *of* 87% (b)
- Additional monitoring will be conducted to verify the stability of the PCB reductions





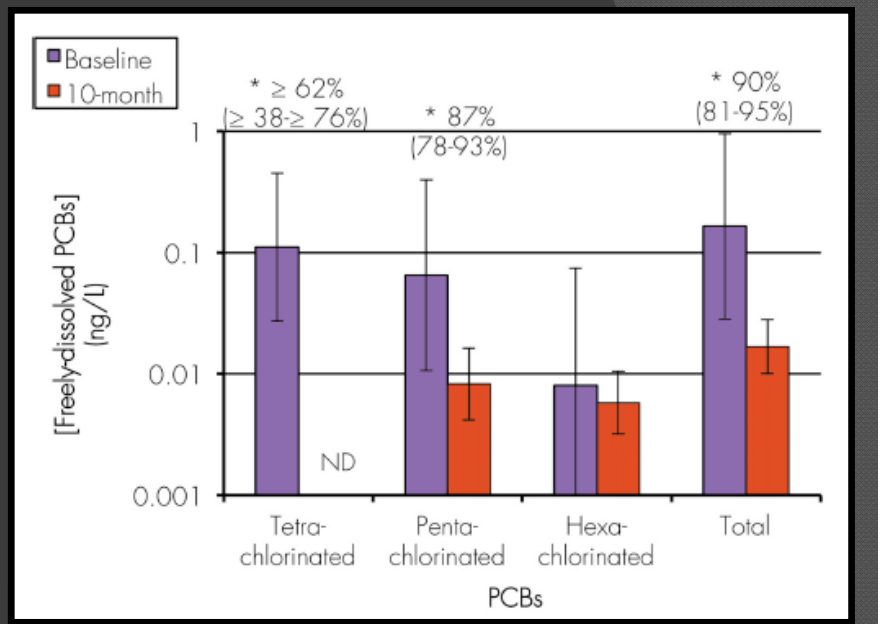
(Grover et al; Poster WP144, Wed)

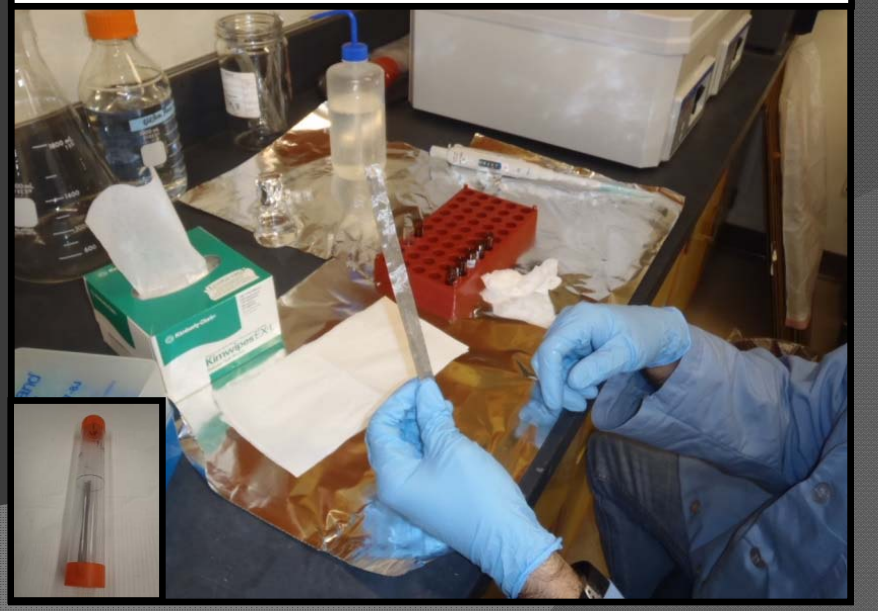
Evaluation of PCB Availability

Sediment Porewater

- Concentration of freely-dissolved total PCBs in sediment also decreased significantly (~90%) following amendment with activated carbon (10-mo)
  - Concentration decreased from 0.165 to 0.017 ng total PCBs/L
  - Tetrachlorinated congeners were not detected (ND) above concentrations 0.03 to 0.13 ng/L during 10-mo survey

(Grover et al; Poster WP144, Wed)

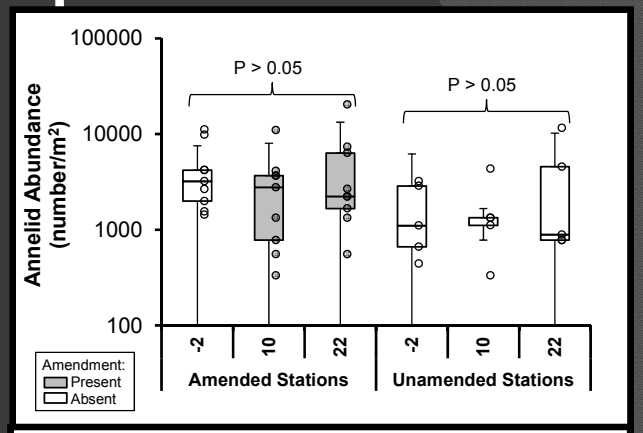


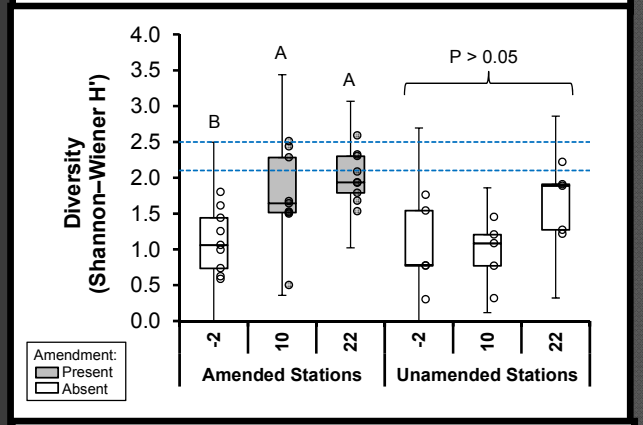


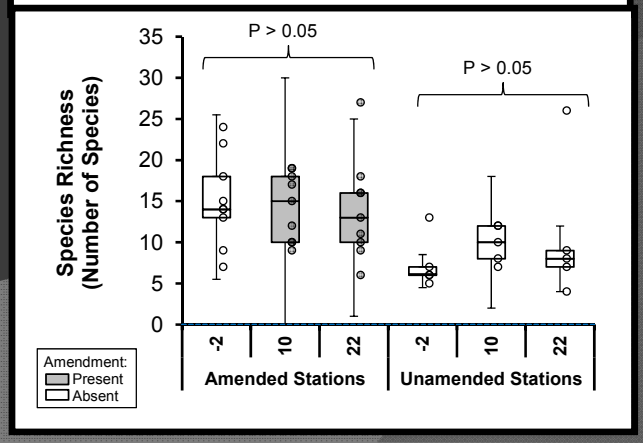
Benthic Community Response

- Baseline (-2 mo) and post-amendment benthic community assessments (up to 21-mo) post-amendment) within and outside placement area
  - Abundance
    - Annelids hypothesized to be sensitive to activated carbon, but no community-level effects detected
  - Diversity
    - Post-amendment diversity increased in the amendment area due to decline in nematode population following amendment placement*
  - Species Richness (Taxa)
    - Not affected by amendment applications

(*Conder et al; Platform 379, Wed am)







Summary...

- So far so good
  - Engineering/Placement
    - Successful under-pier/on slope
    - ~50% of total footprint, 90% of core target area covered
    - Increase in organic carbon in surface sediment
    - Amendment present 21-months post-placement
  - PCB availability reduced (tissue and pore water)
    - 80-90% reduction 10-months post-amendment
  - Benthic Community
    - Amendment did not adversely affect the native benthic invertebrate community, including members (annelids) suspected to be sensitive to activated carbon
- Will the amendment persist?
  - We'll find out. One more round of monitoring in 2015.

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